Journal of Archaeological Science: Reports 35 (2021) 102721

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Southern Jê engravings at Morro do Avencal: Preliminary archaeometrical analysis and interpretation of a rock shelter in Southern Brazil

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ARTICLE INFO

Keywords:
Brazilian Archaeology
Southern Jê
Rock art
EDS/SEM Analysis

ABSTRACT

This paper presents an archaeometric analysis of pigment samples collected into petroglyphs from Morro do Avencal, a rock shelter located in the highlands of southern Brazilian plateau. Raman spectroscopy and Scanning Electronic Microscope associated with elemental analysis by Energy Dispersion Spectroscopy (EDS) identified the use of charcoal and beeswax as pigments (painting) in the petroglyphs. Traces of chalk were also identified, relating to photographic enhancing used to highlight discrete engravings in former studies. Control samples have been used to distinguish the mineralogical composition of the rock support, rich in Barium and Titanium oxides, from the organic pigments on the art-making locales on the wall. This exploratory study is backed up by isotopic analysis of $\delta^{13}C$ on radiocarbon-dated samples, reinforcing the continuous and enduring presence of Jê speaking peoples until very recent times in southern Brazilian plateau, as well as their cultural belonging as regards this peculiar rock art style.

1. Introduction

This paper presents the analysis of some techniques and materials used in the making of engraved rock art at Morro do Avencal, Urubici (Santa Catarina state), located in the southern Brazilian plateau (Fig. 1). In these highlands, climate is humid all year round with warm summer temperatures (max 30 °C) and cold winters (min −7 °C), with occasional snowfall. *Araucaria* subtropical forest and highland grasslands, or *campos*, dominate the study area. The headwaters of this very dissected plateau, located in humid zones of shallow and stony soil around 1800 m a.s.l. (above sea level), flow through incised canyons and forested valleys to the Canoas river, the main watercourse in the central area of an elongated flat open plain, around 1000 m a.s.l.

Morro do Avencal rock shelter is located into one of the several steep sandstone canyons of the region, around 1105 m a.s.l., with a flat sheltered area of approximately 120 m^2 (Fig. 2A). Its vertical walls display a series of engraved petroglyphs, some apparently containing traces of pigments. This paper presents an archaeometric analysis of five samples of black pigment and two samples of white pigment collected into these petroglyphs, and three control samples collected in the parietal support of the rock shelter, and their results.

Riris and Corteletti (2015) carried out the first detailed analysis of these engravings, about five decades after the first reports on the site (Piazza, 1966; Rohr, 1971), applying polynomial texture mapping (PTM) in the recording of the rock art panels. PTM recording, a reflectance transformation image (RTI) technique, resulted much more precise than the drawing of the engravings outlined in the 1960s. Also, this technique has revealed the existence of several eroded motifs never recorded before, bringing out novel compositional aspects unnoticed so far. A variety of engraving techniques have been employed at the site, mostly pecking, abrasion and polishing of the sandstone wall surfaces, and some of these engravings exhibit what seemed to be remains of painting.

The engravings are distributed in four different panels, arranged sequentially from north to south along approximately 40 m of the shelter walls (Fig. 2). Geometric, anthropomorphic and zoomorphic figures can be seen in three of these panels, and the other displays impressive anthropomorphic masks and several triangular and trapezoidal carves. In some of the anthropomorphic motifs, the use of combined techniques confers a three-dimensional quality to the petroglyphs.

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https://doi.org/10.1016/j.jasrep.2020.102721
Received 6 June 2020; Received in revised form 15 October 2020; Accepted 27 October 2020
Available online 24 December 2020
2352-409X/

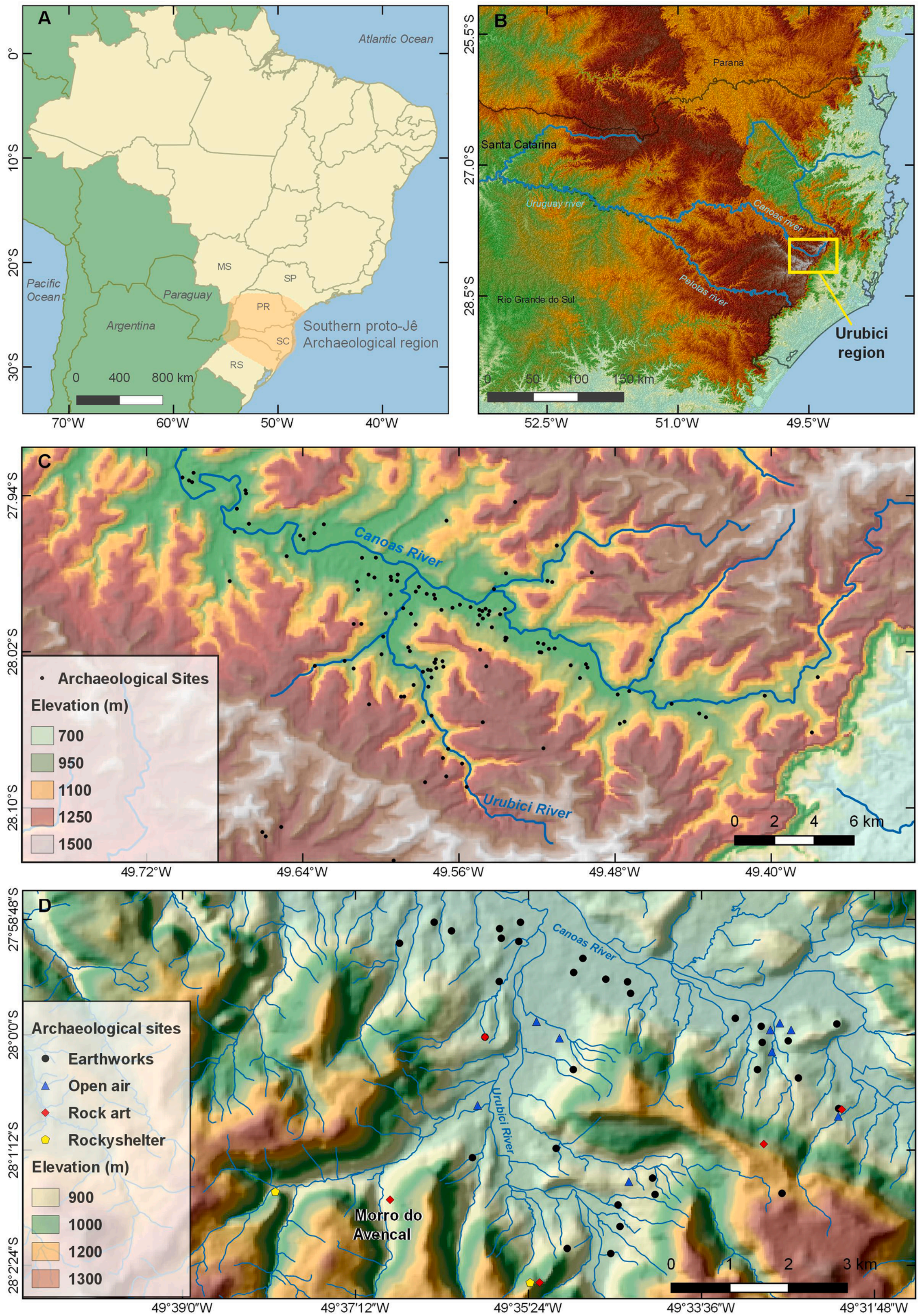

Fig. 1. A. Southern proto-Jê (Taquara-Itararé tradition) archaeological region. B. Urubici archaeological region, in Santa Catarina State. C. Upper Canoas Valley, in Urubici, with a plenty of proto-Je archaeological sites. D. Detail of Urubici region with Morro do Avencal location.

Similar engraved pictograms from other parts of southern Brazil are frequently related to the southern Jê-speaking societies (Laming-Emperaire and Emperaire, 1968; Piazza and Prous, 1977; Prous, 1994). Interestingly, some of the motifs engraved at Morro do Avencal are unique, such as the anthropomorphic masks of panel 1 (Fig. 2B and Fig. 3).

2. The Southern Jê people

Earthen architecture archaeologically identifies the Southern Jê people, including pithouse villages and strategically located mound and enclosure complexes (Copé, 2006a; Corteletti, 2008; Corteletti and Iriarte, 2018; Iriarte et al., 2013; Robinson et al., 2017; Schmitz et al., 2010, 2013; Souza, 2018; Souza et al., 2016b; Ulguim, 2015). In addition to these carefully built structures, they are also related to a peculiar ceramic technology described as Taquara-Itararé Tradition (Beber, 2005), which appears in open-air sites as well (Beber, 2005; DeMasi, 2005; Saldanha, 2005; Wolf, 2016). Collective burials in caves or rock shelters (Brentano and Schmitz, 2010; Corteletti, 2012) and rock art locations (Riris and Corteletti, 2015; Rohr, 1971; Silva, 2001) also correlate to the territories of the Southern Jê societies and their ancestors.

Southern Jê archaeological evidence dates back at least to the first century BC and occupies a vast and ecologically diverse territory stretching from the Atlantic coast to the western Paraná river basin, encompassing most of the southern Brazilian plateau (Noelli and Souza,

Fig. 2. A. Site Overview. B. Panel 1, with anthropomorphic masks and geometric features - diffuse gain PTM image. C. Panel 2, geometric features - static multilight PTM image. D-E. Panel 3, with geometric and anthropomorphic features - diffuse gain PTM image. F. Panel 4, with zoomorphic features - diffuse gain PTM image.

Fig. 3. Panel 1 anthropomorphic masks. A: black pigment found inside the engraving. B: black pigment all over the face – note the engravings of the face painting and *tembetá* (lip piercing).

2017, Fig. 1A). Southern Jê speaking societies are still living in this area, allowing for meaningful cultural connections and long-term indigenous history perspectives, to which this paper aims to contribute.

Several researchers point out that the southern Jê have constituted a highly structured social landscape, with local communities organised around ceremonial and funerary complexes placed in carefully chosen locations. Settlements include large and well-planned pithouse villages, open-air lithic and ceramic locations and parietal art into scenic rock shelters such as Morro do Avencal, discussed in this paper (Copé, 2006b; Corteletti et al., 2015; Corteletti and DeBlasis, 2018; Corteletti and Iriarte, 2018; Iriarte et al., 2008, 2013; Robinson et al., 2017; Saldanha, 2005; Souza, 2018, Souza and Copé, 2011; Souza et al., 2016a, 2016b).

The management of *Araucaria* forest by the Southern Jê populations has long been postulated (Bittencourt and Krauspenhar, 2006; Iriarte and Behling, 2007). It has recently been supported by interdisciplinary studies of archaeology, paleoecology and palaeoclimatology (Robinson et al., 2018) and phylogeography studies of *Araucaria* genome (Lauterjung et al., 2018). These new perspectives reinforce the human presence on environmental changing patterns and into landscape modelling in southern Brazil.

Rupestrian sites from the southern country are generally included in the red-painted small figurines style of the Plateau Tradition, thought of as a product of earlier hunter-gatherer societies. Alternatively, they are related to the usually engraved Geometric Tradition (Prous, 1992), without much concern as regards site function and its regional inception, or possible cultural connections. Many authors attribute this engraved art to the Southern Jê (e.g. Riris and Corteletti, 2015; Rohr, 1974; Silva, 2001) but, despite advances in regional studies, little is known about the stylistic and technological characteristics of the Southern Jê rock art sites. Indeed, rock art sites across this area have a range of different stylistic variations, including anthropomorphic and zoomorphic figures, as well as circular, helical, amorphous, rectangular, triangular, and linear geometric forms (Gaspar, 2003; Schmitz, 1987; Silva, 2001). Despite that, Silva (2001) argues that rock art found all over the plateau and coastal areas of southern Brazil have similar characteristics and, therefore, belong to the same cultural background. Into this paper, the connections between this rock art and Southern Jê people are confirmed for the Urubici area at least and proven active until very recently.

Following previous publications (Piazza, 1966, 1969; Rohr, 1971, 1984), we have carried out a survey locating 124 archaeological sites related to the long-term history of the Southern Jê groups in the upper Canoas valley (Corteletti, 2010, 2012; Labrador, 2018; Fig. 1D). Several pithouse villages have been found along the open plain and its older terraces and surrounding slopes, often near the confluence of larger tributaries. Most sites are at the bottom of the valley, which makes a sharp contrast with the steep surrounding scarps of the plateau (Fig. 1C and D). The large number and diversity of archaeological sites and their long-lived chronology (approx. 1800–100 cal BP) reveal the intensity of the Southern Jê occupation at Urubici region (Labrador, 2018; DeMasi, 2001; Almeida, 2014; Piazza, 1969; Corteletti, 2012). Settlement includes villages, crop locations and polishing/grinding lithic workshops, as well as ceremonial and mortuary places, some of them in rock shelters such as Morro do Avencal (Corteletti, 2012; Corteletti and DeBlasis, 2018). Available chronology also connects the archaeological Jê to the ethnographically known and contemporary Jê speaking societies, thus making a strong case for an extensive indigenous history of the southern Jê peoples.

3. Materials and methods

As the floor of the Morro do Avencal shelter has been severely damaged by previous (not professional) intervening, eight test-pits and some profile cleaning has been performed, inside the sheltered area and immediately outside it. This methodology aimed to determine if some intact archaeological context has remained, hoping to acquire some insight into a possible stratigraphic (occupational) sequencing and date it. Although we have not been able to provide clear diagnostic archaeological contexts, anthropic soils have been detected and dated, as discussed ahead.

Due to the fragile conditions of the engraved sandstone walls from Morro do Avencal, sampling and analytical methodologies were chosen to minimize the impact on the archaeological record and, at the same time, optimize the analyses by multiple proxies. Carried out for the first time in southern Brazilian highlands, it is an exploratory and preliminary study aiming to extract samples without damaging the inscriptions, in order to ascertain the anthropic origin of the thin layers of pigment found in the grooves of the petroglyphs at Morro do Avencal site, as well as their nature and content. In this first experimental effort, the main target was to differentiate human action from natural rock characteristics. This approach does not allow identifying the possible existence of different layers that, frequently, conform rock art sites. Nevertheless, as we shall see, clues for such a behavior have indeed emerged.

Following specific protocols to avoid sample contamination (Gomes, 2015), sterilised and exclusive tools for collection and conditioning of each sample were used (e.g. masks, surgical scalpel, surgical gloves, and crystal polystyrene Petri plates). Samples were preferentially collected from motifs affected by rock fissures and cleavage, and each sample does not exceed 3 mm of maximum diameter, to avoid further damaging (Fig. 4B).

The engravings, distributed in four panels over approximately 40 m of the rocky wall surface, exhibit different taphonomic conditions. Panel 1, towards the north of the site, has approximately 6 m^2 and is composed mostly of anthropomorphic motives (Fig. 2B). Here, four samples (MA_02, MA_03, MA_04 and MA_05) of black pigment and one of white pigment (MA_09) were collected inside the incisions on the rock, plus two control samples from the wall outside the grooves (MA_06 and MA_07). Panel 2, located 12 m to the south, is smaller (approximately 2 m^2), containing geometric motifs, mostly rectangles and squares (Fig. 2C). Panel 3, located further five meters from panel 2, covers about 10 m^2 and occupies a projection of the wall facing north and northwest. Motifs include anthropomorphs and several geometric designs composed of crossed lines, trapezoids, lozenges, squares, asterisks (Fig. 2D and 2E). Panel 4, located at the southern end of the site, is located under a mini shelter lower than the other panels, with glyphs distributed along its wall and ceiling. From this panel has been extracted one sample of black pigment (MA_01) and another of white pigment (MA_10), plus a control sample (MA_08). It covers approximately 7 m^2 of zoomorphic figurines, geometric graphs composed of crossed lines, trapezoids, lozenges, squares, and tens of dots (Fig. 2F).

Preservation differences between these panels are due mostly to the degree of direct exposition to sunlight, rainfall, and wind. The action of these environmental agents on the rock pigments, especially in heating their organic compounds, makes its identification difficult, since it modifies the molecular crystalline structure, metabolizing the evidence from the original compounds.

Samples of black pigment are from two different taphonomic conditions. Sample MA_01 comes from inside the pecking groove of a zoomorphic feature (bird) under the protection of the sheltered Panel 4 (Fig. 4A). The other samples were collected in exposed areas under direct sunlight, rain and wind effects, either inside grooves (MA_02 and MA_03) or at flat polished areas (MA_04 and MA_05). Lastly, to minimise uncertainties regarding blackened and whitish pigments, control samples were used to check the results (MA_06, MA_07 and MA_08; Fig. 4D).

Raman Spectroscopy is a virtually non-destructive technique that identifies the frequency of inelastic scattering of light through atomic groups when subjected to monochromatic light beams (Gaspar, 2003; Pessis, 2003; Russ et al., 1995). Samples were analysed individually in Confocal Raman Microscope Witec alpha 300R, with a lateral resolution of 200 nm and vertical resolution of 500 nm. In order to use samples for different analyses, laser He-Ne intensity was set as 633 nm, thus avoiding losing material with burning and deterioration. The spectrometer has a focal length of 80 mm and is designed for two classes (600 and 1800 grooves/mm). The diameter of the laser beam is approximately 1 mm and the spectral resolution was approximately 0.02 cm^{-1}. The laser power range between 0.2 and 4 mW and the exposure times range between 2 and 5 s with 5–10 accumulations. Raman signals were

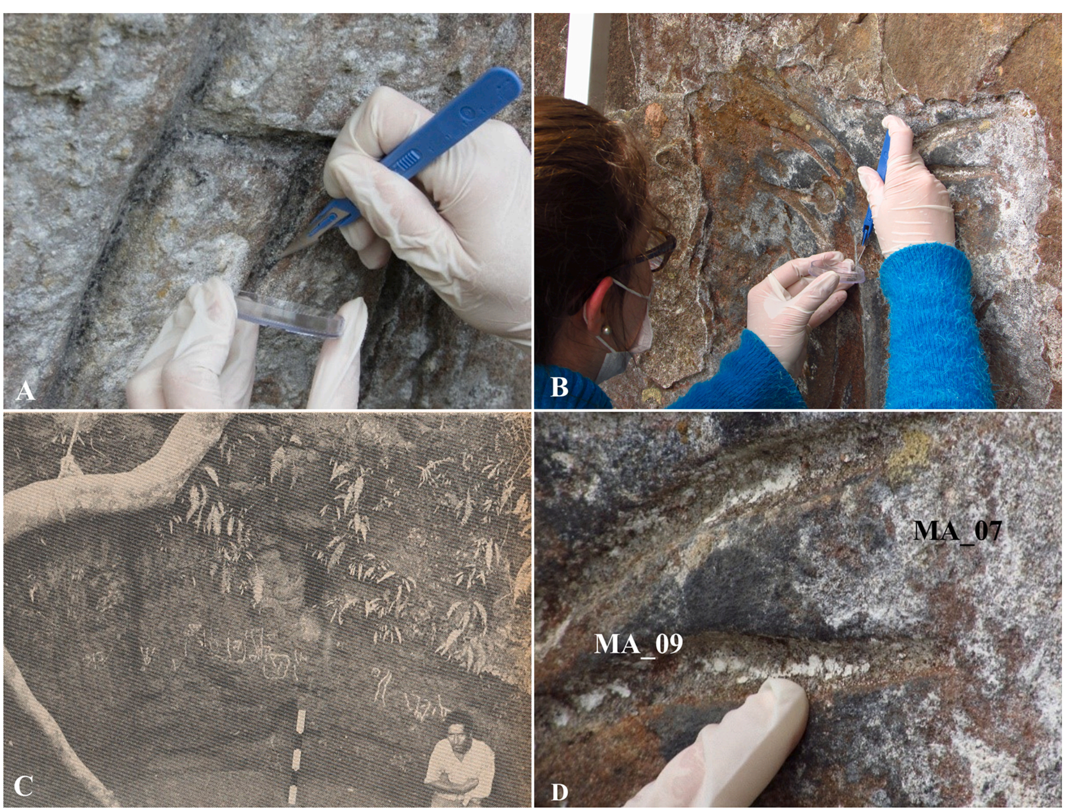

Fig. 4. A. Collecting MA_01 sample of black pigment found in the incision of Panel 4 bird petroglyph. B. Sample MA_3 was collected into a fissure of the sandstone wall, in one of the Panel 1 masks. C. An old image of Urubici 4 nearby pit house site, where white chalk has been used to highlight rock art (Rohr 1974). D. Detail of the white pigment sample: MA_09 is chalk recovered from the engraved incision; MA_07 has been collected into a whitish colouration surface concretion (Ba).

collected through a 50x microscope objective, the spectrometer was calibrated and recorded with silicone at 520 cm^{-1}. Due to the heterogeneous nature of these samples, and looking to understand the diversity of signals, each sample passed by three scans. This procedure also ensures that possible variation in the recorded spectrum might be linked to taphonomic issues, such as low scattering of the metabolism of pigment-forming substances that would be masked by background noise or superimposed on the lithological background (Lopes, 2005).

Afterwards, looking to identify elemental composition and molecular microstructures, samples were analysed in Scanning Electronic Microscope (SEM) with X-ray Energy Dispersion Spectroscopy (EDS), TESCAN VEGA3 LMU, with a resolution of 3 nm and EDS type chemical analysis system (Oxford) with AZ Tech (Advanced) software with 80 mm^2 SDD type detector. Samples have not been covered in gold, looking to preserve it after characterising elemental chemistry. Although this procedure does not give us images in greater structural details, it was possible to distinguish the crystalline structure of the pigments in some samples (MA_01 and MA_09; Fig. 5), and allow re-using some of them for radiocarbon dating. Elemental analysis is fundamental to confirm the compounds identified by Raman spectroscopy, distinguishing archaeological and control samples, especially concerning crystalline precipitation through the bedrock wall.

Following these procedures, multivariate clustering analysis of the EDS data has been performed, using Ward hierarchical method in software *R*, considering the Wt percentages of the elements C, O and Si. These elements were chosen because they are the main components of the crystalline substrate, consisting mostly of quartz ($SiO2$, Scheibe and Teixeira, 1973), present in all samples. They are also useful in distinguishing samples with C contents, such as MA_01, which displays evidence of pyrogenic carbon (charcoal) in all applied methodologies.

Three better-preserved samples containing amorphous pyrogenic carbon (MA_02, MA_04 and MA_05) were sent to the Center of Applied Isotopes Studies of the University of Georgia (CAIS-UG) for radiocarbon dating and related isotopic values.

4. Results

The EDS elemental characterisation has been fundamental for distinguishing between human-applied (anthropic) and natural elements from the control areas of the rock walls. It has been possible to determine the origin of the natural elements detected into the highly porous sandstone matrix of the Botucatu Formation (Fig. 6; see Supplementary Information). Indeed, the most striking feature of the control samples is the presence of Titanium (Ti) and Barium (Ba) oxides. Blackened titanium oxides, as in sample MA_06, seems to have leached from the upper Serra Geral formation, rich in Titanium at the Urubici region (Coelho and Chaves, 2016). In samples MA_07 and MA_08, the presence of Barium (Ba), precipitating as Barium Sulphide ($BaSO4$) in white colour, is relatively common in Botucatu Formation sandstones (Muniz et al., 2007).

Another curious outcome of this study is the presence of white pigments with high concentration of Calcium (Ca), such as in sample MA_09 (Fig. 4D). It confirms the presence of calcium sulphate (chalk), also identified in Raman spectroscopy and SEM analysis. In fact, by the 1960s and 1970s, earlier researchers used to apply chalk into the petroglyphs, to highlight the signs for sketches and photographs (see Fig. 4C for an example). Such a practice, no longer in use, has been, nevertheless, confirmed by this pigment remaining traces investigation.

Sample MA_01, collected from inside a pecked groove of a zoomorphic feature (bird) in the sheltered area at Panel 4, offered greater analytical potential. This favourable taphonomic condition has made possible the identification, in the SEM imagery, of the crystalline structure of pyrogenic carbon, i.e. charcoal (Fig. 5A). This identification corroborates the EDS elemental analysis, with 77% of carbon (C). It also supports the Raman spectral scans, with peaks at 1354 cm^{-1} and 1584 cm^{-1} (Fig. 7A), described in other studies as responses of amorphous carbon compounds and the use of charcoal in pigments (Gaspar, 2003; Gomes et al., 2013; Gomes, 2015; Lopes, 2005; Pessis, 2003; Rull et al., 2014). The SEM image validation of the crystalline structure of sample MA_01 generated correlations with other pigment samples (MA_02 to MA_05), despite the variability of responses of these methodologies.

Also, Raman spectroscopy of the sample MA_01 identified an anomaly around 1774 cm^1, characteristic of organic metabolites related to the use of paint binder for rock paintings in several parts of the world, especially beeswax (Edwards et al., 1996; Edwards and Falk, 1997; Gomes, 2015; Lopes, 2005; see Supplementary Information).

The black pigment samples from the Panel 01 engravings (MA_02 to MA_05) were much more degraded, as observed in the low crystallisation when submitted to SEM, and in the weak Raman bands, when compared with sample MA_01. Nevertheless, it was possible to identify peaks in the regions of the pyrogenic carbon (1300 and 1600 cm^{-1}) and binder related to the use of beeswax (1700 cm^{-1}, Fig. 7B and C). Raman

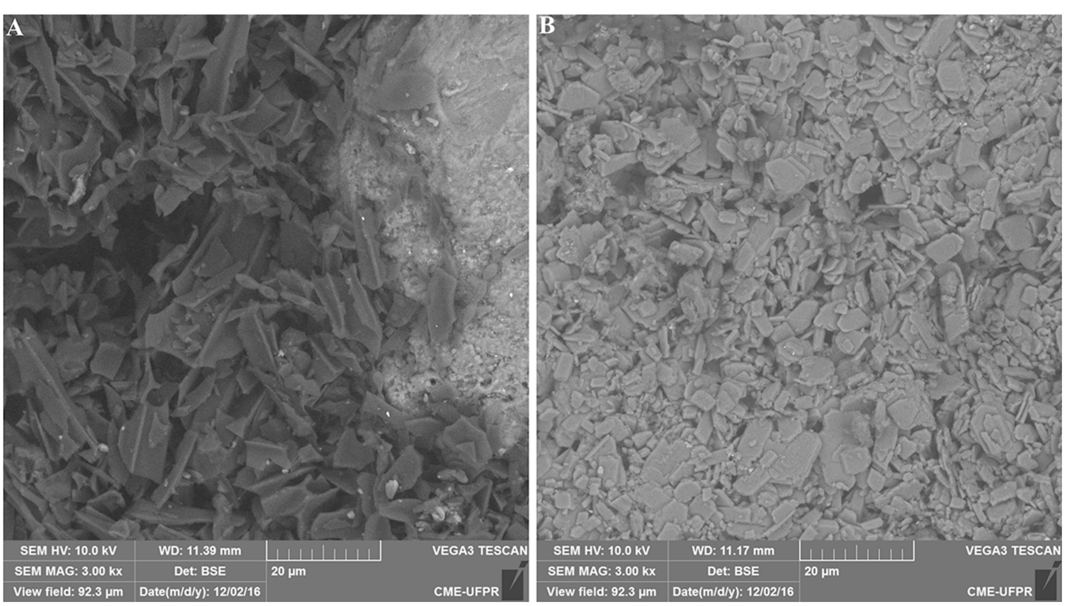

Fig. 5. SEM image of samples (A) MA_01, the crystalline structure of pyrogenic carbon (charcoal); and (B) MA_09, the crystalline structure of calcium sulphate (chalk).

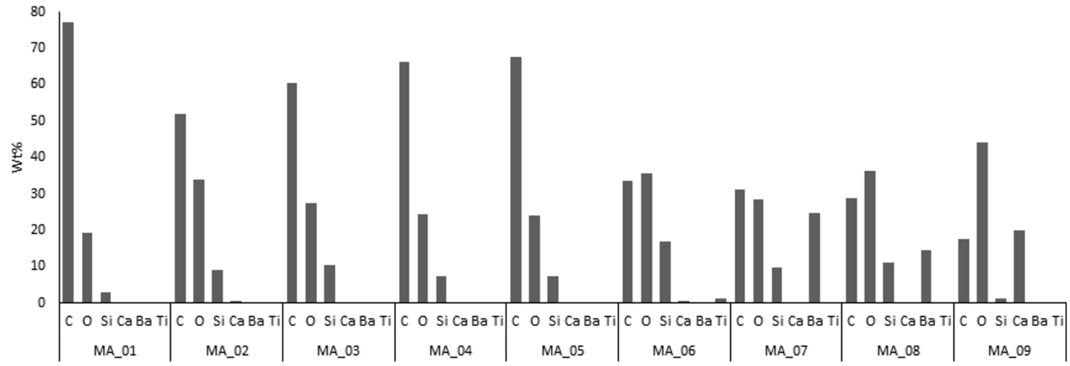

Fig. 6. Samples elemental distribution by EDS method.

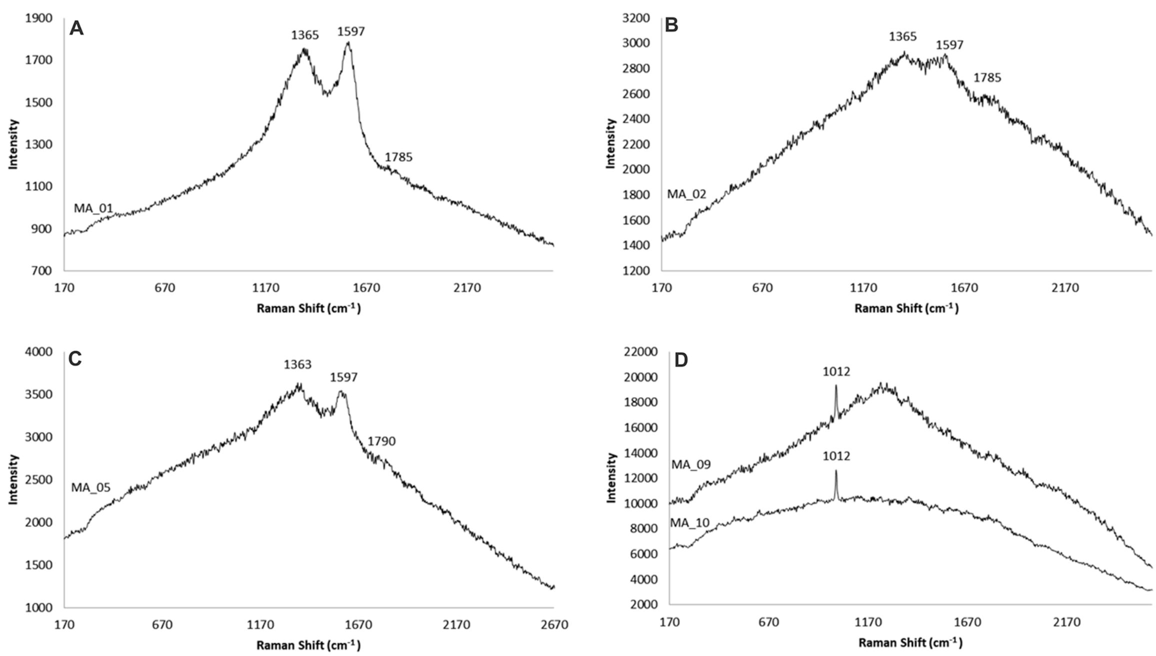

Fig. 7. Raman spectra of the samples (A) MA_01, detail for the peaks at 1365 and 1597 cm^{-1} for the presence of pyrogenic carbon (charcoal) and 1785 cm^{-1} for organic metabolites, such as beeswax. (B) MA_02, detail for the peaks in 1365 and 1597 cm^{-1} referring to the presence of pyrogenic carbon (charcoal) and in 1785 cm^{-1} for organic metabolites, such as beeswax. (C) MA_05, detail for the peaks in 1365 and 1597 cm^{-1} referring to the presence of pyrogenic carbon (charcoal) and in 1785 cm^{-1} for organic metabolites, such as beeswax. (D) MA_09 and MA_10 detail for the peak at 1012 cm^{-1} referring to the presence of calcium sulphate (chalk).

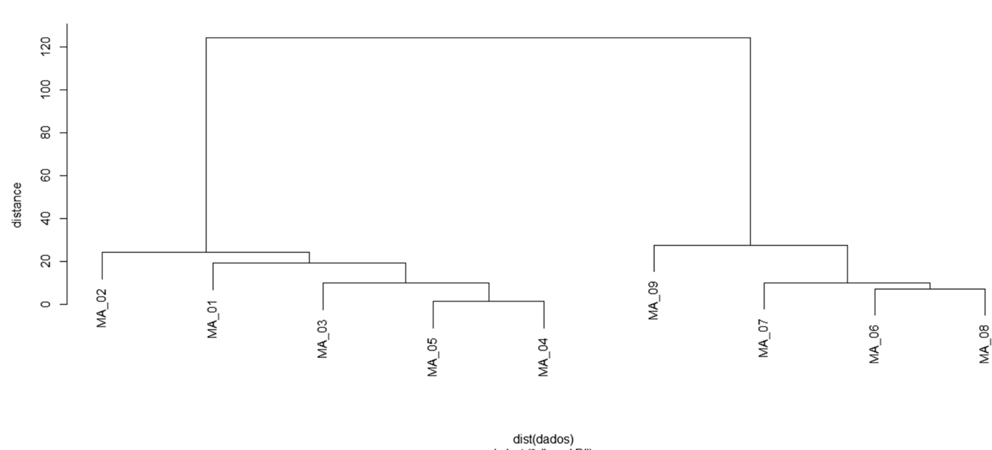

Fig. 8. Clustering samples dendrogram of the elemental composition of C, Si and O by EDS method.

spectroscopy of samples MA_09 and MA_10 brings the same peaks in the 1012 cm^{-1} band, indicating the use of chalk (Lopes, 2005; Fig. 7D). Sample MA_09 has been submitted to EDS analysis, showing high calcium values (Ca), and to SEM imagery, when the crystalline structure of calcium sulphate ($CaSO_4{\cdot}H_2O$) has become evident (Fig. 5B; see Supplementary Information).

Following Raman Spectroscopy and SEM/EDS analyses, samples were submitted to multivariate clustering analysis, which confirmed the hypothesis of pigment use, with a clear distinction between control and archaeological samples (Fig. 8). Samples MA_01 to MA_05, collected directly from the engravings, were grouped by the presence of amorphous pyrogenic carbon. Control samples MA_06 to MA_08 get together due to the presence of macroscopic modification produced by percolated precipitation of minerals, especially Barium sulfate and Titanium oxide. Finally, samples MA_09 and MA_10 were confirmed as evidence of chalk, used for enhancing the archaeological record in the 1960s. The dendrogram displays the results generated by multivariate analysis of elemental concentrations of Carbon (C), Silica (Si) and Oxygen (O), in percentage (%), using EDS method (Landim, 2011; see Supplementary Information).

Six radiocarbon dates have been obtained at Morro do Avencal (Table 1). The upper three dates come from the test pits into the shelter and immediately outside it. They match well with Urubici region Southern Jê chronology, including the historical period. The exception is the first one (UGAMS 30067), which is older than what is known for the Jê horizon (approx. 1800–300 BP). It possibly relates to pre-Jê occupation but, unfortunately, these samples have been obtained from occupation levels with no associated diagnostic cultural materials.[1]

Radiocarbon dating also indicates that the three measured samples of black pigments are modern. Sample MA_02 (UGAMS 30071) is significantly recent and the other two samples, MA_04 (UGAMS 30070) and MA_05 (UGAMS 30069), unfortunately, do not allow the use of standard calibration curves. However, the possibility of being before 1950 CE is high, fuelling some corollaries, discussed in the next section.

Isotopic reference values for C3 plants ranging from $\delta^{13}C$ −30‰ to −26‰, and isotopic reference values for beeswax ranging from $\delta^{13}C$ −26‰ to −23‰ (according to Rossi et al., 1999), make it possible to infer that the isotopic values measured for MA_02 ($\delta^{13}C$ −27,98‰), MA_04 ($\delta^{13}C$ −28.27‰) and MA_05 ($\delta^{13}C$ −28.27‰) indicate that the ink used as black pigment was a mixture of beeswax and C3 plant charcoal.

5. Discussion

Morro do Avencal integrates a broad set of rock art sites in southern Brazil attributed to Southern Jê populations (Rohr, 1984; Silva, 2001). It is, indeed, a very typical and iconic location. As a striking scenic feature, this rock shelter faces sunset (west) and, from it, the view of two other impressive landmarks is possible: the 100 m high Avencal waterfall, approximately 2 km to the south, and the Panelão Peak (1412 m a.s.l.), around 14 km to the north.

Following Southern Jê cosmology, elements such as water and mountain are of substantial importance. Water is the unique element to circulate through the three worlds: of the gods, in the sky; of the living, on the earth surface; and of the dead, in the underground (Rosa, 2005). The mountain, in turn, was the original place from which the twin brothers who founded the Kaingang society have emerged (Veiga, 2006). The choice of this parietal location for drawing petroglyphs and other activities certainly owes much to these aspects of the surrounding landscape, which are integral to interpreting the meaningfulness of this site (Corteletti, 2012; Corteletti and DeBlasis, 2018).

Some of its graphic motifs can be found at other archaeological sites of the region, as in the walls of a nearby pithouse excavated into the sandstone bedrock (Urubici 4 site, Rohr, 1974; Fig. 4C). Similar designs also appear in ceramics incised decoration and body painting of the Southern Jê people (Silva, 2001). It is important to highlight that Morro do Avencal is the only site in southern Brazil where painted petroglyphs have been confirmed so far.

The use of multiple analytical approaches on the samples extracted from the engravings of Morro do Avencal has allowed the identification and correlation of different elemental components, as well as the taphonomic variations between pigments from different areas of the shelter, increasing interpretive potential and minimising uncertainties about the data. The application of three distinct, low impact and non-destructive methodologies in small samples allowed its subsequent use for radiocarbon dating and isotopic values.

This novel application of rock art pigment analytical techniques in this region has revealed, for the first time, evidence for the use of charcoal and animal binders, most probably beeswax. The low spectral response of this binder is due to the taphonomic conditions of the compound, heavily deteriorated and metabolised. In addition, the extremely thin layer of pigment still remnant on the wall has affected its analysis (Edwards et al., 1996; Edwards and Falk, 1997; Gomes, 2015; Lopes, 2005).

Although the choice for small size sampling at eroded areas of the engraved wall has probably increased the low spectral response of this binder, it is important to note that the dating of the samples seems to indicate that the pigment, depending on the subtlety and thickness of the rock matrix, has been preserved just because it is recent. This hypothesis reinforce the perception that this rock shelter has been used up to modern times, in conformation to ethno-historical reports (Rohr, 1972; Lavina, 1994).

Samples of white pigment confirm the presence of chalk residue from rock art recording techniques in the 1970 s; while chalk samples have a $CaSO_4$ composition (Figs. 5B and 7D), control samples are rich in Barium and Titanium (see Supplementary Information).

Radiocarbon dates from test excavations carried out at the shelter floor and immediately outside it, and also from samples of black pigment (Table 1), indicate that Morro do Avencal rock shelter has endured as a prominent and meaningful place for ritual performance of the Jê people into the highlands of the Urubici region (Robinson et al., 2017; Iriarte et al., 2013). Its particular topographical, temporal, ideological and cosmological elements make this place a reference for the cultural behaviors of Southern Jê people in their long-term history - that is, according to Schlanger (1992), a persistent place.

This highland area has seen an extremely late occupation by colonial (Brazilian) society. By the time, the small town of Urubici has been founded, in 1894, the first contacts between *Laklãnõ/Xokleng* (Jê) people who lived in the valley and the colonisers were peaceful. However, as the years went on tension has increased (Rohr, 1972). Lavina (1994) reports several official documents describing *Laklãnõ/Xokleng* assaults on farms, and *bugreiros* (hunting parties against Native Americans) attacks to *Laklãnõ/Xokleng* villages in Santa Catarina state between 1834 and 1927. According to these documents, three massacres to *Laklãnõ/*

Table 1
Radiocarbon dating from Morro do Avencal.

C_{14} age	$\delta^{13}C$,‰	2 sigma cal AD	Lab Code	material
2130 ± 25	−24,05	199–54B.C.	UGAMS 30,067	charcoal
190 ± 20	−29,76	1667-present	UGAMS 30,068	charcoal
120 ± 25	−26,84	1697-present	UGAMS 30,066	charcoal
modern	−28,27	modern	UGAMS 30,069	black pigment
modern	−28,27	modern	UGAMS 30,070	black pigment
modern	−27,98	modern	UGAMS 30,071	black pigment

[1] A few lithic sites related to the Archaic Umbu Tradition, attributed to pre-Jê hunter-gatherer societies, have been found scattered throughout the Urubici area (Corteletti 2012, Labrador 2018). Unfortunately, they have not been dated so far.

Xokleng hamlets located in Urubici have taken place between 1917 and 1918, performed by *bugreiros* troops.

Our recent archaeological investigations in this region (Corteletti, 2010; Corteletti et al., 2015; Corteletti and DeBlasis, 2018) confirm the long-term presence of the Southern Jê people, especially the *Laklãnõ/Xokleng* and their ancestors, from around 2000 years ago up to the first half of the twentieth century, an occupation evinced both by archaeological and historical data. Dating obtained in the black pigment samples indicate that rock art at Morro do Avencal has been performed until the beginning of the twentieth century but, based on three other dates from excavations at this site (Table 1), as well as the wide distribution of this rock art style, probably some of the petroglyphs have been first carved much earlier.

Beeswax, honeycomb, and honey are widely used by Southern Jê populations in everyday life, for food or tool manufacturing (Becker, 1976; Laroque, 2007; Paula, 1924; Rodrigues, 2007; Dias and Jefferson, 2004). These substances are also important in ceremonial situations, as when honey is offered to the dead among the *Laklãnõ/Xokleng* (Silva, 2001), used as an ingredient in ritual beverages among the *Laklãnõ/Xokleng*'s *Móng-ma* (Paula, 1924), or among the *Kaingang*'s *Kiki* (Baldus, 1937). There are several ethnographic reports of beeswax used for waterproofing baskets to transport water or honey (Becker, 1976; Henry, 1964; Lavina, 1994; Paula, 1924; Silva, 2001). Also, as an adequate resin for a burnt finishing on the external surface of ceramic vessels, glue for fixation and repairs (Lavina, 1994), fuel to start the fire (Ambrosetti, 2006), candles (Rambo, 1947) or, yet, a resin for fixing the hair of men (Serrano, 1936).

Despite these abundant ethnographic reports, this is the first confirmed evidence for beeswax in Southern Jê archaeological context and, curiously, with a specific use never mentioned in ethnography. The unique ethnographical reference on paint composition of Southern Jê peoples relates to *Kaingang* of Palmas body painting, who used charcoal, water, and the sticky sap from some grasses for binding (H.H. Manizer in Métraux, 1963). The use of beeswax as a binder in cave paintings is reported on other parts of the Americas (Cerrón, 2006), and Silva (2001) informs that the black body paint of the *Mbya Guarani* is a mixture of beeswax and *taquara* leaf (*Chusquea* sp.) charcoal. Thus, the paint traces found at Morro do Avencal are in conformity to ethnohistorical information on native Jê speaking and other populations of Southern Brazil. The isotopic values of $\delta^{13}C$ for beeswax and *taquara* leaf charcoal (a C4 plant) should be higher than those measured on Morro do Avencal black pigment samples, suggesting that these last ones are probably a mixture of beeswax and C3 plant charcoal.

6. Conclusion

This article has shown archaeometric analysis of ten samples collected in the parietal art site of Morro do Avencal, Urubici, SC (five black pigment samples and two white pigment samples collected into the petroglyphs, and three control samples from the sandstone rocky support). Raman spectroscopy and Scanning Electronic Microscope associated with elemental analysis by EDS identified the likely use of charcoal and beeswax as compounds of the black pigment used in the inscriptions. Isotopic analysis of $\delta^{13}C$ in the samples sent to radiocarbon dating also point the presence of charcoal and beeswax, indicating the possibility that this charcoal has come from C3 plants. The presence of chalk in some samples (commonly used to highlight the inscriptions in the photographic record by researchers in the 1960 s and 70 s) has also been detected. The distinction, observed by using control samples, between the mineralogical composition of concretions in the rocky wall, rich in Barium and Titanium oxides, and the pigments, has helped to distinguish anthropic intervening from natural components of the rock wall.

The best-preserved sample (MA_01, in Panel 4), placed near the ground under a sheltered area, has been protected from direct incidence of wind and sun. In contrast, Panel 1 receives the direct impact of sunlight, wind and rain. Besides, samples collected near these inscriptions display high content of concretions, leached by surface runoff and internal percolation of the sandstone wall. The dating of the black pigment indicates that, due to its subtlety and faintness, paint has only been preserved for being very recent. Thus, it seems likely that we may have analysed the last coat made on these engravings. This inference leads to the perception that the site has been used until very recent times and, connecting archaeological data to local ethnohistorical reports, reinforces the long indigenous history of the southern Jê speaking peoples in this part of Brazil. Although archaeological evidence as recent as the data presented in this paper has not yet been recorded elsewhere in the area, there are plenty of ethnohistorical information confirming the presence of *Laklãnõ/Xokleng* villages, as compiled by Lavina (1994). The appropriate fitting of archaeological and ethnohistorical data at Morro do Avencal and its surrounding territory makes it a very strong case for the historical continuity of Je societies in the area, as a long-lived permanent location and an important reference for their symbolic landscape.

CRediT authorship contribution statement

Rafael Corteletti: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Manoella Souza Soares:** Methodology, Investigation, Formal analysis, Writing - original draft. **Bruno Labrador:** Investigation, Writing - original draft. **Paulo DeBlasis:** Writing - original draft, Writing - review & editing, Funding acquisition.

Acknowledgements

Research was funded by FAPESP/AHRC project 'Jê Landscapes of Southern Brazil: Ecology, History and Power in a Transitional Landscape during the Late Holocene' (2012/51328-3 e 2014/07754-3) and CAPES. Analysis was placed at Centro de Microscopia Eletrônica (CME) da Universidade Federal do Paraná, and CAIS – UG – Alexander Cherkinsky; Marcelo Sabiá and Caroline Medeiros (pictures and fieldwork support); Jonas Gregório De Souza for comments in early drafts.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2020.102721.

References

Almeida, L.C., 2014. Ocupação pré-colonial no planalto catarinense: os sítios arqueológicos do município de Urubici (SC) sob a perspectiva da geoarqueologia. Ph.D. Dissertation, PPG Geografia. Universidade Federal de Santa Catarina, Florianópolis.

Ambrosetti, Juan B. 2006 Os índios Kaingang de San Pedro (Missiones). Ed. Curt Nimuendajú. Campinas.

Baldus, H., 1937. Ensaios de Etnologia Brasileira. Companhia Editora Nacional, Rio de Janeiro.

Beber, Marcus V., 2005 O sistema de assentamento dos grupos ceramistas do Planalto Sul-brasileiro: o caso da Tradição Taquara/Itararé. Documentos 10:5-125. IAP-UNISINOS, São Leopoldo.

Becker, Itala I.B., 1976 O índio Kaingang no Rio Grande do Sul. Pesquisas Antropologia 29. IAP-UNISINOS, São Leopoldo.

Bittencourt, A.L.V., Krauspenhar, P.M., 2006. Possible prehistoric anthropogenic effect on *Araucaria angustifolia* (Bert.) O. Kuntze expansion during the Late Holocene. Rev. Brasil. Paleontol. 9, 109–116.

Brentano, Claucia, Pedro I. Schmitz, 2010 Remanescentes humanos da gruta do Matemático (RS-A-08). Pesquisas Antropologia 68, 121–132. IAP-UNISINOS, São Leopoldo.

Cerrón, Maritza R. 2006 Arte rupestre en el departamento de San Martin. Ph.D. Dissertation. Facultad de Letras y Ciencias Humanas. Universidad Nacional Mayor de San Marcos. Lima, Peru.

Coelho, R.M., Chaves, A.O., 2016. Petrografia e litoquímica de diques máficos mesozoicos e cambrianos de Minas Gerais: Comparações com Basaltos da Província Paraná-Etendeka e com Diques da Suíte Fundão. Geonomos 24, 29–40.

Copé, Silvia M., 2006a. Les grands constructeurs precoloniaux du plateau de sud du Bresil: etude de paysages archeologiques a Bom Jesus, Rio Grande do Sul, Bresil. Ph. D. Dissertation, Paris I, Panthéon-Sorbonne, Paris.

Copé, S.M., 2006. Narrativas espaciais das ações humanas. História e aplicação da arqueologia espacial como teoria de médio alcance: o caso das estruturas semi-subterrâneas do planalto Sul-brasileiro. Rev. Arqueol. 19, 111–123.

Corteletti, R., 2008. Patrimônio Arqueológico de Caxias do, Sul. Ed. Nova Prova, Porto Alegre.

Corteletti, R., 2010. Atividades de campo e contextualização do Projeto Arqueológico Alto Canoas – PARACA, Um Estudo da Presença Proto-Jê no Planalto Catarinense. Cadernos do LEPAARQ (Ed. UFPEL) 8 (13/14):121–157.

Corteletti, R., 2012. Projeto Arqueológico Alto Canoas – PARACA: um estudo da presença Jê no Planalto Catarinense. Museu de Arqueologia e Etnologia. Universidade de São Paulo.

Corteletti, Rafael, Paulo DeBlasis, 2018. Arqueologia Jê do Sul do Brasil: ambiente, sistema, poder e experiência na paisagem de Urubici, Santa Catarina. Rev. Memorare 5(2), 132–164, Tubarão.

Corteletti, R., Dickau, R., DeBlasis, P., Iriarte, J., 2015. Revisiting the economy and mobility of southern proto-Jê (Taquara-Itararé) groups in the southern Brazilian highlands: starch grain and phytoliths analyses from the Bonin site, Urubici, Brazil. J. Archaeol. Sci. 58, 46–61.

Corteletti, Rafael and José Iriarte. 2018 Recent advances in the archaeology of Southern proto-Jê People. In: Smith, C. (Ed.) Encyclopaedia of Global Archaeology, 2nd ed. https://doi.org/10.1007/978-3-319-51726-1_3037-1.

DeMasi, Marco A.N., 2001. Pescadores e Coletores da Costa Sul do Brasil. Pesquisas Antropologia 57, IAP –UNISINOS, São Leopoldo.

DeMasi, M.A.N., 2005. Relatório Final – Projeto de Salvamento Arqueológico Usina Hidrelétrica Campos Novos. Unpublished report available at IPHAN Library, Florianópolis.

Edwards, H.G.M., Falk, M.J.P., 1997. Fourier-transform Raman spectroscopic study of unsaturated and saturated waxes. Spectrochim. Acta Part A 53, 2685–2694.

Edwards, H.G.M., Farwell, D.W., Daffner, L., 1996. Fourier-transform Raman spectroscopic study of natural waxes and resins. Spectrochim. Acta, Part A 52, 1639–1648.

Gaspar, M.D., 2003. A Arte Rupestre no Brasil, 2nd ed. Jorge Zahar, Rio de Janeiro.

Gomes, H., 2015. Arqueometria de Pigmentos da Arte Rupestre – Caracterização mineralógica e técnicas de produção na arte esquemática da Peninsula Ibérica Ocidental. Ph.D. Dissertation. Universidade de Trás-os-Montes e Alto Douro, Portugal.

Gomes, H., Rosina, P., Holakooei, P., Solomon, T., Vaccaro, C., 2013. Identification of pigments used in rock art paintings in Gode Roriso-Ethiopia using Micro-Raman spectroscopy. J. Archaeol. Sci. 40, 4073–4082.

Henry, J., 1964. Jungle People. Vintage Books, New York, A Kaingáng Tribe of the Highlands of Brazil.

Iriarte, J., Behling, H., 2007. The expansion of *Araucaria* forest in the southern Brazilian highlands during the last 4000 years and its implications for the development of the Taquara/Itararé Tradition. Environ. Archaeol. 12, 115–127.

Iriarte, J., Christopher Gillam, J., Marozzi, O., 2008. Monumental burials and memorial feasting: an example from the southern Brazilian highlands. Antiquity 82, 947–961.

Iriarte, J., Copé, S.M., Fradley, M., Lockhart, J., Christopher Gillam, J., 2013. Sacred landscapes of the southern Brazilian highlands: understanding southern proto-Jê mound and enclosure complexes. J. Anthropol. Archaeol. 32, 74–96.

Labrador, B.R.S., 2018. *Sistema de Assentamento Proto-Jê Meridional no Alto Rio Canoas.* Master's thesis. Museu de Arqueologia e Etnologia. Universidade de São Paulo.

Laming-Emperaire, Annette, Joseph Emperaire, 1968. Descobertas de pinturas rupestres nos planaltos paranaenses. Rev. Centro de Ensino e Pesquisa Arqueológica 1, 81–93, UFPR, Curitiba.

Landim, P.M.B., 2011. Análise estatística de dados geológicos, multivariados. Ed. Oficinas de Texto, São Paulo.

Laroque, Luis F.S., 2007 Fronteiras geográficas, étnicas e culturais envolvendo os Kaingang e suas lideranças no Sul do Brasil (1889-1930). Pesquisas Antropologia 64, IAP-UNISINOS, São Leopoldo.

Lauterjung, M.B., Bernardi, A.P., Montagna, T., Candido-Ribeiro, R., Costa, N.C.F., Mantovani, A., Reis, M.S., 2018. Phylogeography of Brazilian pine (Araucaria angustifolia): integrative evidence for pre-Columbian anthropogenic dispersal. Tree Genet. Genomes 14, 36.

Lavina, Rodrigo, 1994 Os Xokleng de Santa Catarina: uma etnohistória e sugestões para os arqueólogos. Master's thesis. IAP-UNISINOS. São Leopoldo.

Lopes, Francisco N., 2005. Espectroscopia Raman aplicada ao estudo de pigmentos em bens culturais: I – Pinturas Rupestres. Master's thesis. Instituto de Química, Universidade de São Paulo.

Métraux, A., 1963. The Caingang. In: *Handbook of South American Indians*, Volume 1, Marginal Tribes, Julian Steward (org). Cooper Square Publishers, New York, pp. 445–475.

Muniz, E.S., Fontoura, S.A.B., Santos, A., Souza, A.L.S., 2007. Equipamento para estudo de redução de permeabilidade em arenitos devido à precipitação química, 4° PDPETRO,. Campinas-SP.

Noelli, F.S., Souza, J.G., 2017. Novas perspectivas para a cartografia arqueológica Jê no Brasil meridional. Bol. Museu Paraense Emílio Goeldi 12, 57–84.

Paula, José M., 1924 Memoria sobre os botocudos do Paraná e Santa Catharina organizada pelo serviço de protecção aos selvicolas sob a inspeção do Dr. José Maria de Paula. In: Annaes do XX Congresso Internacional de Americanistas vol. I, Rio de Janeiro.

Pessis, Anne M., 2003 Imagens da Pré-história – Parque nacional Serra da Capivara. FUMDHAM/Petrobrás.

Piazza, W.F., 1966. As grutas de São Joaquim e Urubici. Florianópolis, UFSC.

Piazza, W.F., 1969. A área arqueológica dos Campos de Lages. In PRONAPA – Resultados Preliminares do Terceiro Ano (1967–1968). Museu Paraense Emílio Goeldi, Publicações Avulsas 13, 63–74.

Piazza, Walter F., André Prous, 1977. Documents pour la prehistoire du Bresil meridional. 2. L'etat de Santa Catarina. Cahiers d'archeologie d'Amerique du Sud. Paris.

Prous, A., 1992. Arqueologia Brasileira. Brasília, Editora da UNB.

Prous, A., 1994. L'art rupestre du Brésil. Bulletin de la Société préhistorique Ariège, Société préhistorique de Ariège.

Rambo, Balduíno, 1947. Os índios rio-grandenses modernos. Anais da Província de São Pedro 10, 81-88, Porto Alegre.

Riris, P., Corteletti, R., 2015. A new record of Pre-Columbian engravings in Urubici (SC), Brazil, using Polynomial Texture Mapping. Internet Archaeol. 38.

Robinson, M., Iriarte, J., Souza, J.G., Corteletti, R., Ulguim, P.F., Fradley, M., Cárdenas, M.L., DeBlasis, P., Mayle, F., Farias, D.S.E., 2017. Moieties and mortuary mounds: dualism at a mound and enclosure complex in the southern Brazilian Highlands. Latin Am. Antiquity 28, 232–251.

Robinson, M., Souza, J.G., Maezumi, Y.S., Cárdenas, M., Pessenda, L., Prufer, K., Corteletti, R., Scunderlick, D., Mayle, F.E., DeBlasis, P., Iriarte, J., 2018. Uncoupling human and climate drivers of late Holocene vegetation change in southern Brazil. Sci. Rep. 8, 7800.

Rodrigues, R.A., 2007. Os caçadores-ceramistas do sertão paulista: um estudo etnoarqueológico da ocupação Kaingang no Vale do rio Feio/Aguapeí. Museu de Arqueologia e Etnologia. Universidade de São Paulo.

Rohr, João A., 1971. Os sítios arqueológicos do Planalto Catarinense, Brasil. Pesquisas Antropologia 24:72, IAP-UNISINOS, São Leopoldo. 1972 Cadernetas de campo originais (1971-1972). Notas sobre o livro Tombo da Igreja de Urubici. Acervo do Instituto Anchietano de Pesquisas – IAP-UNISINOS, São Leopoldo.

Rohr, João A., 1972. Cadernetas de campo originais (1971-1972). Notas sobre o livro Tombo da Igreja de Urubici. Acervo do Instituto Anchietano de Pesquisas – IAP-UNISINOS.

Rohr, João A., 1974. Die vorgeschichtlichen grubenwohnungen in Brasilien. *Jahrbuch der Familie*. Porto Alegre. Sociedade Cultural e Beneficente Padre Reus 178–183.

Rohr, João A., 1984 Sítios arqueológicos de Santa Catarina. Anais do Museu de Antropologia 17, 77–168. Ed UFSC, Florianópolis.

Rosa, Rogerio R.G., 2005. O território xamânico Kaingang vinculado às bacias hidrográficas e à floresta de Araucária. Cadernos do LEPAARQ 4:99-115. UFPEL, Pelotas.

Rossi, Nádia F., Martinelli, Luiz A., Lacerda, Tais H.M., Camargo, Plínio B. De, Victória, Reynaldo L., 1999. Análise da adulteração de méis por açúcares comerciais utilizando-se a composição isotópica de carbono. Food Sci. Technol. 19, 199–204.

Rull, Fernando; Gázquez, Fernando; Medina, Jesús; Sanz, Aurelio; Las Heras, Carmen; Prada, Alfredo; Lasheras, José A. and Calaforra, José M. 2014 Caracterización de pigmentos utilizados en el arte rupestre de la Cueva de Altamira. Macla 19. Revista de la Sociedad Española de Mineralogia.

Russ, Jon, Palma, Russell L., Loyd, David H., Farwell, Dennis W., Edwards, Howell G.M., 1995. Analysis of the rock accretions in the lower Pecos region of southwest Texas. Geoarchaeology 10, 43.

Saldanha, João D.M., 2005. *Paisagem, Lugares e Cultura Material: Uma Arqueologia Espacial nas Terras Altas do Sul do Brasil.* Master's thesis Faculdade de Filosofia e Ciências Humanas. PUCRS, Porto Alegre.

Scheibe, Luiz F. and Victor H. Teixeira. 1973 Geologia de Santa Catarina. In: Levantamento de reconhecimento dos solos do estado de Santa Catarina. UFSM-SUDESULSECR, pp. 17–27.

Schlanger, Sara H., 1992. Recognising persistent places in Anasazi settlement systems. In: Rossignol, J., Wandsnider, L. (Eds.), Space, time and archaeological landscapes, New York, Plenum Press, pp. 91–112.

Schmitz, Pedro I., 1987. Prehistoric hunters and gatherers of Brazil. J. World Prehistory 1, 53–126.

Schmitz, Pedro I., Fulvio V. Arnt, Marcus V. Beber, André O. Rosa, Deisi S. Farias, 2010. Casas subterrâneas no Planalto de Santa Catarina: São José do Cerrito. Pesquisas Antropologia 68, 7–76, IAP-UNISINOS, São Leopoldo.

Schmitz, Pedro I., Jairo H. Rogge, Raul V. Novasco, Natalia M. Mergen, Suliano Ferrasso, 2013 Rincão dos Albinos, um grande sítio Jê Meridional. Pesquisas Antropologia 70, 65–131. IAP-UNISINOS, São Leopoldo.

Serrano, Antonio, 1936. Etnografia de la Antígua Provincia del Uruguay. Editora Paraná, Entre Rios, Argentina.

Silva, Sergio B., 2001. Etnoarqueologia dos grafismos Kaingang: um modelo para a compreensão das sociedades Proto-Jê meridionais. Ph.D. Dissertation. PPG Antropologia Social, Universidade de São Paulo.

Souza, Jonas G., 2018. Rethinking households, communities and status in the southern Brazilian highlands. J. Anthropol. Archaeol. 52, 44–58.

Souza, Jonas G., Copé, Silvia M., 2011. Novas perspectivas sobre a arquitetura ritual do planalto meridional brasileiro: pesquisas recentes em Pinhal da Serra, RS. Rev. Arquelogia SAB 23, 104–117.

Souza, Jonas G., Corteletti, Rafael, Robinson, Mark, Iriarte, José, 2016a. The genesis of monuments: resisting outsiders in the contested landscapes of southern Brazil. J. Anthropol. Archaeol. 41, 196–212.

Souza, Jonas G., Robinson, Mark, Corteletti, Rafael, Cárdenas, Macarena L., Wolf, Sidnei, Iriarte, José, Mayle, Frank, DeBlasis, Paulo, 2016b. Understanding the chronology and occupation dynamics of oversized pit houses in the Southern Brazilian Highlands. PLoS ONE 11 (7), e0158127.

Ulguim, Priscilla F. 2015 Analyzing cremated human remains from the southern Brazilian highlands: interpreting archaeological evidence of funerary practice at mound and enclosure complexes in the Pelotas River Valley. In: Timothy Thompson

(Ed.) The Archaeology of Cremation: burned human remains in funerary studies. Oxford, Oxbow Books, pp. 173–212.

Veiga, Juracilda, 2006. Aspectos Fundamentais da Cultura, Kaingang. Ed. Curt Nimuendajú, Campinas.

Wolf, Sidnei, 2016. Arqueologia Jê no Alto Forqueta e Guaporé/RS: um novo cenário para um antigo contexto. Ph.D Dissertation, PPG em Ambiente e Desenvolvimento, UNIVATES, Lajeado.

Zuch Dias, Jefferson L., 2004. A Tradição Taquara e sua ligação com o índio Kaingang. Master's thesis, IAP-UNISINOS, São Leopoldo.